A DAY AT A SHIP-YARD.

Ship on the Stocks, building; and Ship in Dock for repairs.

To the inhabitants of a sea-girt country, such as England, a ship must ever be an object of interest and admiration, whether regarded as the substitute, the more than substitute, for stone-walls as a defence, or as the channel whereby commerce is carried on with foreign countries. As a work of art, too, a ship has at all times and in nearly all countries called forth expressions of wonder. We may or may not, as we please, give credence to the opinion expressed in Dryden's lines:—

> "By viewing Nature, Nature's handmaid, Art,
> Makes mighty things from small beginnings grow;
> Thus fishes first to shipping did impart,
> Their tail the rudder and their head the prow;"

but certain it is that, whether fishes were or were not the first ship-draughtsmen, the art of constructing barks capable to a greater or less degree of contending with the winds and waves, has been known from a very remote period.

The steps by which excellence in this art has been attained, the countries in which the art has been most fully developed, and the present state in which it exists in foreign countries, form collectively the materials for a history of naval architecture, a vast subject, into which it is not proposed here to enter. Neither does naval warfare, with its combined miseries and triumphs, fall within the scope of this article. We propose to give a description, derived from personal observation, of an establishment which ranks, we believe, at the head of the private ship-building yards in this country; to convey an idea of the general nature of the operations conducted in such establishments; and to trace, as far as the necessary limitations of popular language will admit, the order of processes by which the more important parts of a ship are constructed and put together.

The ship-yard to which we allude is that belonging to Messrs. Green, Wigrams, and Greens, to whose courtesy we owe the facilities for working out the plan of this number. The locality of the yard is somewhat remarkable, occupying, as it does, a nook on the banks of the Thames at the eastern extremity of the metropolis. We hardly know whether to place it in London or in the country, for the smoke of the one and the green fields of the other almost meet at this spot. Leaving this matter, however, as one of no importance, we will take an imaginary trip down the river to Blackwall, in order to indicate the position of this yard relatively to what is termed the 'port' of London generally.

In proceeding eastward from London Bridge, past the Custom-house, the Tower, the St. Katherine's Docks, and the London Docks, we find the northern shore of the river occupied chiefly by wharfs and by traders engaged more or less in matters connected with maritime affairs; but it is not till we arrive somewhat farther down the river that ship-building yards, properly so called, are seen. A northerly bend in the river, from nearly opposite the London Docks, constitutes that part which is called 'the Pool,' and which brings us to Limehouse. Here we find a remarkable curve in the river towards the south, and near this spot are the

yards of Messrs. Curling and Young, and other ship-builders, some for ships generally, some for iron steam-boats, &c. The river, for the next three miles of its course, is so tortuous that it almost encircles and encloses a tongue of land called the Isle of Dogs; a curvature which comprises within its limits Limehouse Reach, Greenwich Reach, and Blackwall Reach,—*Reach* being a term which watermen and others apply to particular parts of the river. Whether or not it is true, as old Stow tells us, that one of our early kings kept his hounds in this neck of land, and that their constant barking procured for it the name of the Isle of Dogs, is a problem which we will not wait to solve, but will proceed onward to the eastern extremity of this little peninsula, passing a few smaller ship-yards in our way. Here we come to the eastern boundary of the West India Docks, which stretch nearly across the narrowest part of the Isle of Dogs; and a short distance onwards brings us to the yard and docks of Messrs. Green, Wigrams, and Greens, occupying a river-frontage of a quarter or from that to a third of a mile. Beyond this we arrive at the quay or wharf in front of the eastern terminus of the London and Blackwall Railway; with the Brunswick Hotel on the left, the entrance to the East India Docks on the right, and the well-known mast-house (a tall red building of which we shall have more to say presently) in the rear, together with numerous ships in the East India Docks. As a general statement, therefore, we may say that this dock-yard occupies the principal part of the tract of ground separating the East India from the West India Docks, opposite to that part of the Kentish coast called Bugsby's Marshes, between Greenwich and Woolwich.

With regard to the position of this yard on the land side, little need be said. High Street, Poplar, leads down to the immediate neighbourhood of the yard; and the Blackwall Railway, for a part of its distance, skirts it on the north; indeed the railway passes through a portion of ground once belonging to the yard. The lofty chimney belonging to the railway is very near the mast-house, and both are separated from the yard by the railway itself.

Such, then, is the locality of these premises. The private history of commercial establishments does not in general fall within the scope of our articles: but there are circumstances connected with the past history of this yard which are not only interesting in themselves, but serve to explain a certain link of connection between the yard and the East India Docks.

The existence and active operations of this ship-building yard extend back through a period of a hundred and ninety years; for we find that during the Protectorate of Oliver Cromwell the yard was in the possession of Sir Henry Johnson, a liberal man, who seems to have contributed much to the improvement and benefit of the neighbouring hamlet of Poplar. During the Commonwealth, and the reigns of Charles II., James II., and William and Mary, Sir Henry Johnson and his son, who was also knighted, appear to have been much engaged in building the government ships; for there are records still left of about fifteen men-of-war, of from 50 to 70 guns each, built in the yard before the reign of Queen Anne. Strype, in his edition of Stow's 'Survey,' makes frequent mention of the two Sir Henry Johnsons, one or both of whom existed in his time; and also gives us a few quaint anecdotes and details relating to the yard or to its neighbourhood, which, however, are of too trifling a nature to be quoted here. The history of the yard during the early part of the last century is not very clearly to be traced; but Lysons, in his 'Environs of London,' states that the elder Sir Henry Johnson died in 1683; that the second Sir Henry succeeded to the property; and that on the marriage of the daughter of the latter to the Earl of Strafford, the possessorship of all the estates and property passed into the Strafford family.

Just a century ago, the name of Mr. Perry first appears as the owner of the yard; and in the family of the Perrys it remained for about half a century, during which period many of the men-of-war employed in the American war, and in the earlier stages of the revolutionary war, were built for the government at this yard. About the year 1789, we first hear of a commercial dock built in immediate connection with the yard. Ever since the great fire of 1666, the port of London had remained almost unaltered with respect to docks or havens for shipping; and the merchants began to experience great inconvenience from the limited facilities afforded in this respect. Under these circumstances Mr. Perry constructed a dock which he called the 'Brunswick Dock,' adjoining the north-east boundary of his building-yard. This dock was a commodious quadrangular basin, capable of containing at one time twenty-eight East Indiamen and fifty or sixty ships of smaller burden. On the southern quay, which was eleven hundred feet in length, were cranes for landing guns and heavy stores; on the east quay were conveniences for receiving blubber from the whale-ships, as well as coppers for boiling, and warehouses for storing the whale-bone; on the west quay was erected the mast-house, which still remains a conspicuous object from the river, and the purpose of which, as we shall hereafter more fully explain, was to provide a more convenient apparatus for masting ships than that which is generally employed.

Such was Perry's 'Brunswick Dock,' which appears to have been employed as well for government as for private commercial purposes; for cavalry were often embarked from the quays of this dock during the war-like transactions in the latter part of the last century. But the Brunswick Dock did not long remain private property, as the time soon approached when it became part of the East India Docks. Up to the year 1800, not one of the splendid public docks now situated on the northern bank of the river was in existence; but a spirit had sprung up and gone abroad which speedily led to the formation of these conveniences for maritime traffic. A company of West India merchants opened, in the year 1802, the West India Docks, across the northern part of the Isle of Dogs, from Blackwall to Limehouse; about the same time the Corporation of London opened the City Canal, also across the Isle of Dogs; two years later another company of merchants opened the London Docks, between the Tower and Shadwell; and lastly, in 1806, a company of East India merchants opened the East India Docks, including, as a component part, the Brunswick Dock, which the Company purchased of Mr. Perry. The East India Docks consist of an import and an export dock, the latter of which was the Brunswick Dock. By this arrangement the mast-house, situated on the western quay, became likewise the property of the East India Dock Company, in whose possession it still remains.

These transactions relative to the Brunswick Dock did not disturb the regular progress of ship-building in the adjoining yard; for it appears that throughout the war the building-slips were constantly occupied with war vessels and East Indiamen. Indeed so active were the exertions at one time, that in the year 1813 no less than ten ships of war and one East Indiaman were launched from the yard within twelve months. As we have wished to touch upon these matters only so far as they elucidate a few important points in the past history of the port of London, it will be unnecessary to allude to the changes of proprietorship in the yard since the time of Mr. Perry, farther than to observe that the accession of Mr. Green, and after-

wards of Sir Robert Wigram to the firm, placed the proprietorship in the families of those gentlemen, in whom it still remains, under the names of Messrs. Green, Wigrams, and Greens.

We have to apologise to the reader for keeping him waiting so long outside the gate of the ship-yard; but we have thought that the preceding details, by explaining some of the external relations of the yard, will render what is to follow better understood. We will suppose the reader, then, to have accompanied us on the Blackwall Railway (for the great world of London is almost too far westward to admit of the excursion on foot), and to have been set down at the Poplar station, within three or four minutes' walk of the yard. In Brunswick Street, on the eastern side of the way, we perceive the gateway leading to the yard, over and on the left of which is an old family mansion, once, we believe, the residence of Sir Henry Johnson, and, in all probability, constantly occupied since his time by one or other of the partners in the firm.

On proceeding within the entrance gates, past a porter's lodge, the dwelling-house just alluded to lies on the left hand, while the offices and counting-houses, together with another dwelling-house, lie on the right. We soon get past these, and then find ourselves in the open yard of the premises, a large expanse of ground, occupying not less than thirteen acres. Here a multitude of objects all crowd upon the eye at once, presenting a scene of uncommon bustle and liveliness. Immediately on the right is a range of buildings apparently occupied as warehouses. Beyond these is the river, glistening in the sunshine, that is, if the weather be kind enough to admit the sun to peep through the clouds. Between the river and the eye, at short intervals, and along a great extent of shore, are seen ships of various sizes, and in all the various stages of construction, from the small steamer, to the large East Indiaman—from the mere shell of frame-timbers, to the majestic ship just about to be launched; and also old ships undergoing repairs. Between these ships and the spot where we suppose ourselves to be standing near the entrance, the ground is occupied, here and there, with enormous piles of timbers, some cut to the forms required by the shipwrights, others partially sawed and hewn, and others in a rougher state Glancing the eye round towards the left, we catch sight of a building in which a large clock serves as a monitor to all the workmen, and on the left of which is a shed where some of the timbers are cut. In the background, and towards the northern boundary of the yard, are numerous large buildings, separated from one another by tracts of ground covered in most parts by piles of wood. A third dwelling-house, occupied by one of the partners in the firm, is seen also in this direction; and the mast-house, the lofty chimney belonging to the Railway, and the shipping in the East India Docks, appear to skirt the wall of the yard.

A living scene is also presented to the eye at this spot, for on all sides are seen workmen plying the ingenious hand, and the lusty arm too, in the operation of ship-building; some standing on scaffolds at the sides of the ships; some 'converting' the timbers, that is, sawing them to the required shapes; some conveying or superintending the conveyance of timbers from one place to another; some stripping off the old copper from ships under repair; some bringing new sheets of copper to supply its place; smiths in this spot, mast-makers in that; and scores of others which we should find it no easy matter to enumerate. But when one o'clock strikes: here is a change! It is almost worth a dinner to see the hive of workmen flocking out to *their* dinner. We happened to be near the entrance at such a moment, and could not help remarking the striking change in the appearance of the yard after four or five hundred workmen had thus left it in the course of a few minutes. All became perfectly silent and lifeless, and the huge ships had a temporary respite from the beating and battering to which they had just been subject. As two o'clock approaches, straggling workmen come in by ones, twos, and threes; and by a few minutes after two, the stream of industry is pouring back again to the ships.

Such is the general aspect which the yard presents to the first view of a visitor. We will now, therefore, in company with the reader, ramble through the numerous departments of the establishment, noticing the various purposes to which the different parts of the yard are appropriated.

After entering at the outer gate, and passing the counting-house, we will turn to the right, and visit the range of workshops and store-rooms, extending from thence to the river. The first room which need be enumerated is the office of the ship-draughtsman, who is a kind of architect, employed in drawing the plans and arranging the forms and dimensions of ships, preparatory to the operations of the shipwrights. In this room are a few small models of ships, together with the necessary apparatus and drawing instruments for preparing the plans on paper. The operations of the ship-draughtsman are, as we shall explain presently, much more of a mental than a mechanical character, and, therefore, the room in which he is engaged presents little peculiar to attract our notice.

From the draughtsman's room we passed into a large and singular-looking room, called the *mould-loft*, or *moulding-loft*. It is about a hundred feet long and forty or fifty wide, rather shallow, and lighted by about twenty windows, ten on each side. The floor of this room is remarkably flat, smooth, and clean, and is chalked in every imaginable direction with lines, some straight and others curved, intersecting each other at angles of different degrees. A part of this floor, free from chalk lines, is separated from the rest by a ledge, and on this part are fixed carpenters' benches and stools, with the necessary arrangements for sawing and preparing wood-work. It is evident, at a first glance, that the chalked floor is a kind of sanctum, a place not to be defiled by the tread of dirty shoes. Over head is seen, resting on cross-beams, a large assemblage of pieces of thin wood, in most cases long, narrow, and curved. The operations carried on in this room are midway between that of preparing the drawing and that of actually building the ships. The purposes of the chalk marks on the floor and of the thin pieces of wood will be explained farther on.

Beneath the mould-loft we entered, among other rooms, one in which a number of little boys were busily

engaged in 'spinning oakum,' a process respecting which we may say a few words. When the various cables, stays, shrouds, ropes, &c. belonging to a ship have gone through their term of service, and are no longer strong enough to be used, they are cut up into pieces, and then pulled asunder, all the hempen threads being loosened and disentangled one from another. In this state the hempen threads are called *oakum*, which is of different qualities, according as the original rope was or was not tarred. This oakum is sent to the yard in bundles or hanks, and boys are then employed to roll —or, as it is termed in the yard, 'spin'—it into loose portions called 'threads.' A small bundle of fibres is rolled by the hand on a sloping board, till it assumes the form of a loose irregular kind of rope, averaging probably about an inch in thickness. These 'threads' of oakum are subsequently driven into the crevices or seams in the outside of a ship, to prevent the entrance of sea-water.

Adjoining the oakum-shop is a capstan-shop, a place where the ponderous capstans for ships are made. Here we saw an elegant-looking mahogany capstan, intended for the quarter-deck of a vessel then in progress. The capstan, being intended for moving heavy weights, must necessarily be of great strength, while its position on the quarter-deck leads to the desire of giving it somewhat of an ornamental character. It therefore constitutes a separate kind of work both from that of the shipwright and that of the ship-joiner, and is carried on in a distinct shop. Near this spot is also the copper warehouse, in which the sheets, bolts, and other articles of copper are stored away, under the care of the foreman of the copper department. In the course of building a ship, a great number of copper bolts, varying from half an inch to an inch and a half in diameter, are employed; these are cut to the proper lengths from bars kept in the copper warehouse. Patent alloyed metals, composed of copper and zinc, are sometimes used in parts of the ship, and these, as well as articles of copper only, are served out to the workmen from this warehouse.

Over the copper warehouse is a sail-maker's shop, where the canvass and necessary apparatus for making sails are deposited. In front of all these warerooms and shops the ground of the yard is occupied with heaps of wood, intended for different purposes, some to be employed in various departments of ship-building, and some—useless in other respects—intended as billet or fire-wood to be used at sea.

Proceeding onward towards the river, we fell in with some workmen making trenails, or tree-nails, and

wedges. A trenail is a wooden substitute for a bolt or nail, and is regarded as a thing of much importance in ship-building. The frame-timbers of a ship, forming its skeleton, are, as we shall hereafter explain, covered inside and out with thick planks, and these planks are fastened to the timbers almost wholly by trenails, the copper bolts employed being comparatively few in number. These trenails, so far from being made of any odd pieces of waste wood, are formed of the soundest oak, whose grain is straight and regular. They vary in size from a foot and a half to three feet in length, and from one to two inches in diameter, according to the size of the vessel, or to the part where they are to be employed. The pieces of oak which may be selected for this purpose are first sawn to the proper length; the trenail-makers then rip each piece into a number of smaller pieces, and finally reduce them to a tolerably cylindrical shape by means of spoke-shaves, occasionally passing a ring over each piece to regulate the diameter. These trenails are generally kept for many months, to season, before they are employed in the ship. Those pieces of oak whose shape or direction of grain does not qualify them for trenails, are cut into wedges, for the use of the shipwrights in various parts of their operations; and those which will not be available even as wedges are consigned to the billet-heap.

Near the spot which we have just passed are the buildings connected with the smithery. First we meet with the coal-house, filled with the fuel necessary for the operations of the smiths; and next to it the building where the swarthy sons of Vulcan are at work in an atmosphere by no means enviable. The articles made in this shop do not comprise either the ships' anchors or the chain cables, for the making of these are distinct trades, never, we believe, carried on in a private ship-building yard; but they consist of the numerous other pieces of iron-work used in the construction of a ship. The most important of these, perhaps, are the iron *knees*, which connect the beams beneath the deck of a ship with the sides, and which are a kind of bracket, with branches extending in horizontal and vertical directions, perforated for the reception of bolts. These knees are made of iron bars or plates welded together to the proper thickness and width, and fashioned to the required shape. Smaller articles, in great number and variety, are made in a similar manner, the operations being conducted almost in precisely the same way as in a common smith's shop, but on a larger scale. The fierce fires of small-coal built upon the ground, the bellows for exciting the heat, the anvils, the huge sledge-hammers—some weighing nearly thirty pounds,—all are seen here, on a scale which seems to rank midway between that of a common smithery and of an anchor-smith's shop. A separate shop, behind the other, is devoted to the casting of such articles as are formed of cast-metal, and to the cutting, turning, &c. of others in which neatness of appearance is required. It need hardly be observed, that these shops are black, smoky, and hot, a necessary result of the operations carried on there.

Adjoining the smithery is an ironmonger's shop, stored with all kinds of ironmongery for the use of the yard. The circumstance generally strikes a stranger on visiting large establishments of this kind, that the whole is divided into departments as distinct from one another as if they were under different proprietors. In this yard, for instance, the copper and iron stores, however similar they may seem to be in their nature, are in two distinct departments, kept in distinct buildings, and placed under the control of different foremen, each of whom is responsible for the disposal of the property placed under his care. It is evident that, were some such plan as this not adopted, great confusion and uncertainty would prevail, involving frequently a serious misuse of materials. In the ironmonger's shop

not only bolts, nails, screws, &c. are kept, but also tools, such as saws, axes, adzes, hammers, augurs, shovels, &c.

By scrambling over timbers and planks, at the imminent danger of our shins, we next reached the last building in this range, appropriated to the reception and storing of rigging; and beyond this is a small wharf or shed, where articles may be landed from the water.

We have now reached the river side, and find ourselves in view of a very pretty bend in the river, presenting Greenwich Hospital and the surrounding objects in one direction, and the course to Woolwich in the other. The river-frontage of the yard stretches nearly in a direction south-west and north-east; and as we are now at the extreme south-west corner, we will continue our ramble to the north-east extremity, keeping as close to the river as we can.

Within a few yards of the south-west corner, we came to a building-slip, where the frame-work belonging to a vessel of three or four hundred tons burden was being set up. It may perhaps be as well to explain here what is meant by a 'building-slip.' When a ship is about to be built, it is necessary to select a spot of ground from whence the vessel, when finished, may be readily passed into the water. For this purpose, a sloping tract of ground is dug or prepared, larger than the full dimensions of a ship, and at right-angles to the river. This channel is level with the ground at the upper end, but is several feet beneath that level at the lower end, and open to the water. On this inclined slip of ground a ship is built; and at a certain stage in the progress, the gates, which had shut out the water from below, are opened, and the ship launched into the river. Such then is the nature of a building-slip. The one to which we allude is probably about a hundred and thirty feet long by thirty broad; and on it was the rude skeleton of a vessel, formed of curved oak timbers, and supported by shores, poles, and other mechanism.

We then passed over a platform placed across the mouth of the slip, to a kind of quay or wharf on the other side, occupied chiefly by timbers, planks, and other materials for building. This narrow strip of ground occupies the space between the slip just described and a large well-built dry dock nearly three hundred feet long and about twenty in depth. This dock is different, both in shape and purpose, from the building-slip. It is an excavation entirely below the level of the ground from end to end, slightly inclined towards the river, and open to it at the lower end, where folding gates shut off the communication when required. Docks of this kind are not employed for building ships, but for repairing them; and the arrangements for docking are as follow:—When a ship is about to be brought into dock, a row of blocks are laid along the bottom of the dock; and the gates are opened at or about the time of low water. As the tide rises, it flows into the dock to the same level as the river; and when there is a sufficiency of water in the dock, the ship is floated into it, and guided as nearly as can be into the centre. While the tide is going down again, the water flows gradually out of the dock, and the ship sinks deeper in consequence; so that by the time low-water has again arrived, the dock is nearly emptied of water, and the keel of the vessel rests on the blocks beneath. In the mean time preparations have been making for securing the ship in her proper position, by shores, ropes, &c., so that she shall stand vertically on her keel; and at or about low-water the gates are shut, not again to be opened until the repairs of the vessel are finished. In this way a ship is dry-docked, and workmen can then descend into the dock, and examine every part of the ship's bottom down to the keel. The dry-dock of which we are now speaking is a double dock; that is, the length is sufficient to receive two large vessels at the same time. Here we saw two vessels, one an East Indiaman undergoing the process of re-coppering, and the other a smaller vessel in course of repair. In the former, tiers of stages were built round the hull of the vessel; and men were busily engaged in stripping off, by means of a kind of adze, the old and worn copper from the planking, in order to replace it with new.

Separated from this large dock by a narrow piece of ground is another dry-dock, smaller in size, but constructed in a similar manner. Here was another East Indiaman undergoing repairs of a very extensive kind, on which a number of men were employed; some re-trenailing the outer planks, some repairing masts, &c.

Next to this dock is a building-slip, from which, about the middle of April last, the steam-vessel Princess Royal, of 700 tons burden, was launched. After a ship has been once launched, she is brought back to one of the dry-docks, where the finishing operations are conducted. A building-slip, after a launch, remains unoccupied until arrangements are made for laying down a new ship, when the ground is cleared, and the blocks laid for the keel of the new vessel. At a few yards eastward of this slip is a third dry-dock, similar in every respect to the one on the opposite side of the slip, and, like it, occupied by a three-masted vessel in course of repair. But the next dock we come to is of a different kind, being a wet-dock. Here barges and boats, laden with timber and other stores for the use of the yard, enter from the Thames, and proceed to a kind of basin in the centre of the yard, round which are quays where the goods may be landed, and the water of which serves as a mast-pond in which masts are kept.

On crossing this wet-dock, we came to another slip, on which an East Indiaman is in course of building. This fine vessel, which is called the Agincourt, is of about a thousand tons burden, and will probably be launched before this number makes its appearance. Shipwrights and ship-joiners were busily engaged upon it; the former driving the trenails through the planks and timbers (a process which is not done until the trenail holes, made with an augur, have been well aired and seasoned) or caulking the seams with oakum; and the latter putting up the interior fittings of the vessel.

Proceeding eastward from the Agincourt we came to a large space of ground filled with an enormous quantity of oak in the rough state. Whole trunks of trees, portions of trunks, and large branches, some of the most tortuous shapes, were heaped up to a height of twelve or fifteen feet, just in the state they left the forest. These were British oak-trees, landed on the quay of the yard, and waiting to be converted into frame-timbers, beams, &c. for ships. Adjoining this timber-quay, and farther within the yard, are sheds and saw-pits wherein the trees are cut up to the desired forms and sizes.

Our progress eastward next brought us to another building-slip, where was another East Indiaman, the Southampton, precisely equal and similar to the Agincourt, and, like it, advancing rapidly toward completion. This part of the yard appeared the most busy and life-like of all, for the saw-pits and sheds, and the yards belonging to them, are bounded on either side by the two slips on which the large vessels were in course of construction.

When we come to speak of the process of building ships, we shall illustrate many of our remarks by reference to these two vessels, which we have seen in different stages of their progress, and the fine proportions of which render them conspicuous objects in the yard.

Next to this was another slip, unoccupied at that time; but beyond it was one in which a steamer of nine

hundred tons burden was in progress. This steamer was somewhat farther advanced than the vessel at the west extremity of the yard having some of the planking laid on; but not so far advanced as the Agincourt and the Southampton. Beyond this slip was a fourth dry-dock, the most eastward of the whole; and in this, as in the others, was a large three-masted vessel undergoing repair. This dock is bounded by another quay, filled with oak timber in the same manner as the one between the two new slips, and contiguous to another range of saw-pits. And after having passed this we arrive at the eastern extremity of the yard, separated only by a public road from Lovegrove's Brunswick hotel.

We have now traced the whole extent of the premises on the water-side, and have next to notice the buildings in the middle and on the northern side of the yard. The yard is somewhat of a triangular shape, of which the two sides already traced are tolerably straight, while the third one is somewhat curved. In returning from the eastern extremity along this curved boundary, we come to a coal-house and a smith's shop, similar to those in the western range of buildings, and more contiguous to the vessels in the eastern part of the yard. Farther on are the buildings occupied by the boat-builders and the ship-joiners. In various parts of the space between the ships and the northern boundary of the yard are buildings devoted to several different purposes. One is the mastmaker's shop, a large building where masts, yards, bowsprits, &c. are made. A second is a steaming-house, where planks are steamed

preparatory to being laid outside the timbers of a ship; the steaming is effected in square wooden trunks, about thirty feet long, provided with iron doors at one end, which are lifted up by balance weights, and on the opening of which planks are slid into the trunks, to be afterwards exposed to the action of steam. A third building contains a range of saw-pits, similar in arrangement and in purpose to those already mentioned. The open spaces between these several buildings are occupied with heaps of wood—here trees waiting to be squared—there prepared timbers ready for the shipwrights—at another place planks and deals—and at another several thousand trenails placed on a stage to get seasoned. We wander between and among those heaps of wood, and at length arrive at the entrance from whence we started, having visited in our journey pretty nearly all the different parts of the yard.

Thus far have we endeavoured to convey to the reader an idea of the mode in which a large ship-building establishment is arranged. But we hope to be able to do something more than this. We propose to follow, in a cursory and popular manner, the routine of processes by which a large ship is built, so far as to show the relative dependence of one department on another. The art of ship-building involves some of the most intricate considerations which any of our manufacturing arts present; and therefore anything like an exposition of its mathematical principles is wholly foreign to our present object, which is to give a few plain details that a plain man may understand.

In the first place, then, let us suppose that a merchant orders a ship, intended for a particular line and kind of traffic, to be built by a ship-builder. The mode of measurement, by which an agreement is made between the parties, is rather singular, and is by no means easily understood by those who are not familiar with the general details of shipping. It is by *tonnage*, and is supposed to represent the number of tons of cargo which the proposed vessel will carry. Tonnage is estimated sometimes by bulk, but more generally by weight; a ton by bulk being equal to forty cubic feet; and a ton by weight equalling twenty cwts. There are certain formulæ employed by ship-builders, whereby the tonnage is calculated from the length, breadth, and depth of the vessel; but these formulæ seldom give the real tonnage, that is, the real amount of cargo which the vessel will carry; because two vessels exactly equal in length, breadth, and depth—measured as those dimensions usually are—may have very different internal capacity, owing to different curvatures of the hull. A ship will sometimes carry more cargo than her 'tonnage' indicates; sometimes less; and therefore the word tonnage is to be regarded only as a rough approximation to the burden which the vessel will carry.

Still, however, the 'tonnage' is always one of the items of agreement between the builder and the owner, partly from the circumstance that when a vessel is registered, the tonnage is made to indicate its rank or class. In addition to this, the dimensions of the vessel about to be built are agreed upon, as well as the thickness and quality of the more important timbers, the thickness of the planks laid on the outside of the timbers, and other details of a more minute kind.

The specification of the vessel being thus drawn up, the ship-draughtsman commences his labours, which are of a parallel nature to those of an architect in common building. He prepares drawings of the vessel in various points of view, so as to represent the dimensions not only of the vessel itself, but also of the principal timbers composing it, and also the curvatures of those timbers.

The draughtsman having prepared these working drawings, generally on a scale of about a quarter of an inch to the foot, the next thing is to prepare a working *mould* of the ship, as large as the ship itself, in the mould-loft. The mould-loft floor is in most instances large enough to receive half the length of the intended vessel, with the whole height; and on this floor the draughtsman chalks a large number of lines, derived from the working drawings, but enlarged to the full dimensions of the vessel. These lines, generally speaking, represent the exact dimensions and curvatures of the timbers required to form the vessel; and when all the lines necessary for one-half the length of the vessel are laid down, say the bow end, another series is then laid down, on the same floor, for the stern end; the two series intersecting and mingling among each other in every part. Practice enables the draughtsman to distinguish one series from the other, and thus obviate the necessity of having a mould-loft floor equal to the length of a large ship. When these lines, which amount to a large number, and present nothing but a confused assemblage to the eye of a stranger, are laid down, thin pieces of American deal, about three-quarters of

an inch in thickness, are cut and adjusted to the curvatures of the lines, different pieces being joined end to end to produce the requisite lengths. These pieces of deal, which are called *moulds*, assist the sawyers in cutting the oak to the required sizes and curvatures for the different timbers of a ship; and there are certain marks on each piece which further this object. Let us suppose that one of the curved timbers is to be twelve feet in length, one foot thick, one foot wide, and so tortuous in form that its curvature is not circular, and none of its angles are right angles: in such case the piece of pine which forms the mould will give the curvature of the timber, while certain marks on its surface indicate the places where bevellings and angles are to be made from directions given on another board. On these principles the construction of the moulds proceeds, until a sufficient number of pieces is prepared to guide the sawyer in cutting all the timbers of the ship. For a large East Indiaman the number of moulding-pieces thus required is more than a hundred, each of which is marked and numbered in various ways.

The mould of the ship being thus prepared, the next operation is to cut up the oak and elm trunks to the proper dimensions for the various parts of the ship. This is called 'converting,' and is a process requiring great art and judgment; for the wood must be selected not only with a view to avoid waste, but also that the grain of the wood, in preparing a curved timber, may be cut crosswise as little as possible, since such a mode of cutting would greatly weaken the timber. It is, therefore, desirable that a crooked trunk be selected for preparing a curved timber, and that the crookedness of the one correspond as nearly as may be with the curvature of the other. The superintendence of this department is in a person possessing much experience and knowledge of the quality of different woods, and of their relative fitness for the several timbers of a ship. When this superintendant or 'converter' has selected the proper wood, the operation of sawing proceeds nearly as in a common saw-pit. The trunk of the tree is laid across a frame-work in the usual manner, and two men, one above and the other below, cut the wood by means of a long saw. The thin deal mould is used as a constant guide in cutting; the curvature, the breadth, the thickness, and the angles, all being regulated either by the mould itself or by the marks and directions chalked or painted on it. In a place where so much timber is used as in a ship-building yard, it might at first thought be imagined that machine-worked saws would be used; but the curvatures and angles of the timbers are so extremely varied, not only in different timbers, but also in different parts of the same timber, that the precision and regularity of machinery would be here thrown away, and indeed unavailable.

So far, then, we may suppose the principal timbers to be cut. This operation is effected in saw-pits covered by sheds, of which there are three in various parts of the yard to which our attention has been directed. As the timbers are wanted, they are conveyed to the building-slip, or that spot of ground on which the construction of the ship takes place. When the timbers are thus removed, they pass from the control of the 'converter' to that of another superintendant or foreman, who is the ship-builder or shipwright properly so-called.

The building-slip is prepared for the operations in the following manner:—The ground having been cleared and made tolerably clean, a row of blocks is laid down from end to end of the slip, the length of the blocks being transverse to or across the slip. The blocks are of oak, placed one upon another, to the height of three or four feet, and secured together. These piles of blocks are ranged along the slip, at distances of about five or six feet apart, and the upper surfaces of all the blocks are so adjusted that they shall be in one straight line, but inclining slightly downwards towards the river, the inclination being about five-eighths of an inch to a foot of length. Great care is taken in laying down these blocks, as they form the support,—the work-bench, in fact,—on which the whole ship is afterwards built, the keel being laid down immediately upon the blocks.

In order to understand the succession in which the parts of a ship are put together, it is useful to notice certain points of comparison between a ship and the human skeleton. The keel is the back-bone of a ship, and the frame-timbers are the ribs; the ribs forming an arched exterior to the whole of the body or hull, and the keel forming the longitudinal column to which the ribs or timbers are attached. The keel is, therefore, the principal part of the vessel, and the one above all others whose strength and security are indispensable to the safety of the vessel. From this circumstance, and from the position of the keel at the lowest part of the vessel, it constitutes the first part of a ship laid down on the slip. The keel is made of elm, and is of such length, except in small vessels, that no single tree will form it; and, therefore, two or more pieces are joined together, or, as it is termed, *scarfed*, end to end, until the required length is produced. This scarfing is a kind of overlapping, the under part of one piece and the upper part of the other, or the right side of one and the left side of the other, being cut away near the ends, and the cut or scarfed surfaces bolted together. For an East Indiaman of a thousand tons burden, such as the Agincourt and the Southampton, of which we before spoke, the keel is about a hundred and forty feet long, fourteen inches wide, and fifteen deep. For a steamer of the same burden the length is several feet greater, since steamers are generally longer and narrower than sailing vessels of equal burden.

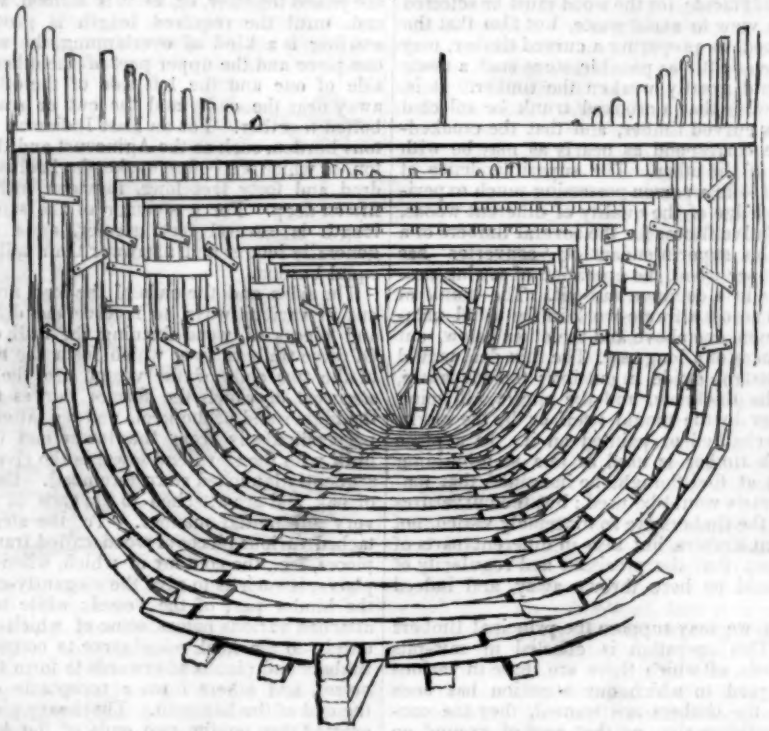
The sides and the ends of the keel are grooved and cut in various ways, to receive the different timbers and pieces of wood forming the hull of the vessel. Of these timbers two, which form the main supports of the two ends of the vessel, are the *stem* and the *sternpost*, of which the former curves upwards from the higher end of the keel, and the latter rises almost perpendicularly from the lower end (for a ship is built with the stern-end towards the river, and is consequently launched stern foremost). Both are formed of oak, and are attached to the ends of the keel in a very substantial manner. To the sternpost are attached various pieces of wood, called transoms, fashion-pieces, &c., the contour of which, when fixed in their places, is such as to give the elegantly-curved form to the hinder part of the vessel; while to the stem are attached various pieces, some of which fit it more securely to the keel, some serve to connect it with the timbers and planks afterwards to form the sides of the vessel, and others form a receptacle or support for the end of the bowsprit. The heavy pieces of timber erected thus on the two ends of the keel are hauled up to their proper positions by pulleys and tackle, and then shored up by poles from the ground, to prevent them from sinking.

Along the keel, nearly from end to end, are fixed stout timbers, called *floor-timbers*, at right angles with the length of the keel, and slightly concave on their upper surface. They are placed a few inches apart, and constitute, as the name imports, the floor of the ship. As there is a general upward curvature of the ship towards each end, the floor rises in a similar manner, and would thus leave a vacancy between the end floor-timbers and the keel; but this vacancy is

filled up with solid wood, called *dead-wood*, constituting a firm foundation. The floor-timbers may be regarded as the lower part of the ribs of the ship; and above them spring up the various pieces forming the remainder or vertical parts of the ribs. No wood can be found so large, so curved, or so strong as to form the whole curved rib; and, therefore, each rib is built up of separate pieces, the general name of which is *futtocks*; thus we have the first, second, third, and perhaps fourth futtock, each being a distinct piece of timber, but all collectively forming one rib, or one 'frame of timbers.' These pieces are placed, some end to end, and others side to side, in such a manner that the joint of two ends of timber may have a support of solid timber at its side. Various means are adopted for joining the pieces end to end, but those which are placed side by side are bolted together with bolts.

As the various futtocks curve more and more upwards, till the upper one, or 'top timber,' reaches to the top of the hull of the ship, it must be evident that all the pieces forming one rib or 'frame of timbers' are very ponderous, especially if the vessel be large. The arrangements, therefore, are regulated according to the dimensions of the vessel. If it be large, the pieces, after being fitted together on the ground, are raised up singly, or perhaps two bolted together; but if it be small, three or four pieces may be bolted together on the ground, and raised as one piece. But in whatever way this part of the matter be arranged, the other operations are nearly alike. All the pieces to form one rib are adjusted and fitted to each other on the ground, and are lifted from the ground by strong tackle. The curvature and weight of the pieces is such, that after being raised and adjusted to their places, they must be secured from falling either inwards or outwards; for the former of which purposes planks called *cross-spalls* are nailed to the upper ends of the timbers, at right angles to the keel, and stretching across from one side to the other; and for the latter, planks called *rib-bands* are placed nearly horizontal round the outside of the ribs at various heights, and are shored up by poles fixed in the ground beneath.

In this manner the ribs or frames of timbers are raised one after another, from end to end of the vessel, the two halves of each frame, that is, the two parts springing from opposite sides of the keel, being raised nearly at the same time, so as to maintain the top timbers at the proper breadth across the vessel. In this stage of the proceedings, the interior shell of the vessel presents the appearance represented in our concluding cut. We have given an *interior* sketch, because it shows more



[Frame-Timbers of a West India Trader (400 tons).]

clearly the relative position of the parts. At the bottom, just above the keel, are the floor timbers, ranged at right angles to it, and projecting some distance beyond it on either side. At the ends of these timbers are the various pieces or futtocks forming the ribs, jointed and bolted together at different parts of their heights. The ribs rise to different and irregular heights, afterwards to be adjusted; and across, from the upper part of the timbers on one side to the upper part on the other, are the spalls, the temporary wooden braces which keep the opposite sides at their proper distances.

But six o'clock has arrived, and our "day' is ended. All are leaving their work. The shipwrights, the mast-makers, the boat-builders, the joiners, the smiths, the caulkers, the trenail-makers, the oakum-spinners —all have finished their day's labour, and the busy hum of active industry is about to be stilled. One day is too short for the building of our ship. We will therefore leave the rough frame-work, the skeleton, the assemblage of back-bone and ribs, for the present; and will on a future occasion invite the reader to spend with us a second "day at a ship-yard."